Decade IV., No. 84. A letter from the Rev. Wm. Hirst dated Fort St. George, E. Indies, February 25, 1761, offers a careful drawing of a leaf-insect with the remark:

Nature seems to have provided for its security by giving it so strong a resemblance to Blades of Grass among which it is frequently found.

Decade V., No. 60. In a letter dated St. Petersburg, 21 Oct./1 Nov., 1768, in which Leonard Euler alludes to his blindness, occur these words:

As the British Parliament were pleased to reward so generously the slight researches which I had made on the Lunar Theory.

Decade V., No. 80. A letter, dated Rio de Janeiro, November 30, 1768, from Captain James Cook to Dr. Morton, secretary of the Royal Society, wherein Cook writes:

The account we gave of our Selves of being bound to the Southward to observe the Transit of Venus (a Phenomena they had not the Idea of) appeared so strange to these narrow-minded Portuguese that they thought it only an invented Story to cover some other design we must be upon.

Decade VI., No. 40. On March 24, 1774, a paper was read by Edward Spry, a well-known surgeon of the day, explaining his antiseptic treatment of amputations by the use of a special dressing, "preventing putrescence."

Decade VI., No. 119. Professor John Winthrop, of Cambridge, Mass., described, in a letter dated November 16, 1774, a pictorial hieroglyph inscribed on a rock twenty miles south of Boston, on the Taunton River.

Decade VIII., No. 1. Writing to Sir Joseph Banks, Sir William Herschel names a new star, Georgium Sidus.

Decade IX., No. 27. A paper of 19 pages communicated by Pierre Laporterie under date of August 14, 1786, and entitled "Saphir crystal, susceptible de l'étoile a six raions"; not printed.

Decade X., No. 65. Paper by Sir William Herschel on the "Quintuple Belt of Saturn"; read December 19, 1793; not printed.

Decade X., No. 70. Letter of Alessandro Volta regarding Galvani's discoveries; read in January, 1794; not printed.

Decade XI., No. 93. An account of the Andaman Islands and their inhabitants, by Captain Archibald Blair. 82 pages and map; read April 4, 1799.

Decade XII., No. 28. Description of what he calls a pulmonary calculus, by Philip Crampton. This concretion was seven inches in diameter and weighed 845 grains.

In addition to the names mentioned above, the following are especially noteworthy: John Abernethy, Abbé Jean Jacques Barthélemy, G. B. Beccaria, Comte de Buffon, Charles Burney Mus. Doc., Hon. Henry Cavendish, Duc de Chaulnes, Richard Chenevix, Erasmus Darwin, Sir Humphry Davy, Sir William Hamilton, Rev. John Lightfoot, Jean Hyacinthe de Megalhaens, P. L. M. de Maupertius, Rev. Joseph Priestly. The index contains more than fifteen hundred names, and enables the student to refer without delay to each paper or letter in the collection.

GEORGE F. KUNZ

SPECIAL ARTICLES

A REVISED CLASSIFICATION OF THE NORTH AMERICAN LOWER PALEOZOIC[1]

CLASSIFICATIONS of stratigraphic subdivisions are bound to change with the expansion of our knowledge of detail, so that the most recently accepted must still be regarded as a tentative one, to be replaced by a better one when needed, and the knowledge of facts warrants it. The generally accepted classification of the Lower Paleozoic of North America, proposed by Clarke and Schuchert in 1899, is now in part out of harmony with known facts, while recent interpretation of previously known facts still further suggests the desirability of modification. For *the Cambric system* Clarke and Schuchert retained essentially the classification of Walcott, which, so far as it is applicable to the facts, is a perfectly satisfactory one. The Lower Cambric or Georgian, however, is typically developed only in the Appalachian and western provinces together with the corresponding regions of northeastern and southern Asia. The Atlantic province both of America and Europe

[1] Abstract of a paper read before the joint meeting of the New York Academy of Sciences and eastern geologists, April 6, 1908.

is known to be distinct, and the Holmia fauna of this province has few, if any, types in common with the Olenellus fauna of what might be called on the whole the Pacific province and its various intracontinental extensions. For that reason it would be well to restrict the term Georgian, and its paleontological equivalent, *Olenellus fauna,* to the Pacific province, and to adopt Matthew's term, Etcheminian (including Coldbrookian) for the Lower Cambric of the Atlantic province of America and Europe. For the corresponding fauna the term *Holmia fauna* should be adopted, since the term Olenellus fauna, now generally applied to this *fauna without true Olenellus,* is not only incongruous, but inevitably misleading; for it implies physiographic conditions which are now known not to have existed.[2] The Middle Cambric best known is that of the Atlantic province with its Paradoxides fauna. For this, the recognized term Acadian is most appropriate. This name, used by Matthew for the lower division of his St. John group, is thus extended to include the lower half of the Johannian, or middle division of that group. It might be desirable to use a distinct name for the Middle Cambric of the Pacific (inclusive of Appalachian) province, since these provinces were perhaps even more distinct than in Lower Cambric time. The Upper Cambric was for a long time called Potsdamian. Recognizing the unsuitableness (except in a historic sense) of this name, Walcott has proposed Saratogan to replace it. Though much better than the old name, this is still extremely unsatisfactory, because at Saratoga only the upper and in many respects least characteristic portion of the series is known. It is doubtful if the Saratoga section represents more than the Tremadoc division of the European Cambro-Ordovicic transition; and aside from *Dicellocephalus,* its trilobite fauna scarcely represents the Upper Cambric.

[2] It should be noted that the North Scottish occurrence of the Olenellus fauna is clearly distinct from the Atlantic province, as repeatedly pointed out by Geikie. It probably belongs to an Arctic extension of the Pacific province.

On the Atlantic coast, the upper Johannian and the greater part of the Bretonian of Matthew's St. John group represents a typical Upper Cambric series in close harmony with that of Europe, with which it shows a striking paleontologic correspondence. The best development is on the island of Cape Breton, where its thickness approaches a thousand feet, if it does not exceed that, and where it includes the characteristic faunal zones of Europe. The upper part of the Bretonian of Matthew includes basal Ordovicic beds, the line between this and the Cambric being generally drawn at the summit of the zone with *Asaphellus homfrayi,* the equivalent of the Tremadoc. This section forms a better standard for the Upper Cambric than any other known in America, and the name *Bretonian* would be most appropriate for it. Its meaning would have to be extended so as to include the upper part of the Johannian of Matthew, which term would then be discarded, while the beds above the Tremadoc horizon should be separated from it. This readjustment would not be very different from that which makes Acadian in its wider sense include the lower half of the Johannian, in addition to the Acadian in its narrower lithologic sense. Since the provinces of the Upper Cambric were less distinct, one name would suffice, but that should be Bretonian or some other equally appropriate name, rather than Saratogan or Potsdamian.

The *Ordovicic system* has undergone a variety of classifications. At present the one generally accepted includes the Beekmantown and Chazy in the Lower, as Canadian; the Black River and Trenton in the Middle, as Mohawkian; and the remainder as Cincinnatian or Upper Ordovicic. This classification is out of harmony with stratigraphic and paleontologic facts. Stratigraphically, the Canadian represents some five thousand feet of calcareous strata (where developed to a maximum), while the Mohawkian includes scarcely six hundred feet. The Cincinnatian as now understood is also less than a thousand feet thick, and is in part a phase of the Upper Mohawkian. The Canadian includes two distinct faunas, while the faunas

of the Mohawkian and Cincinnatian are essentially a unit.

In the Mohawk Valley less than five hundred feet of Beekmantown occur, but in the southern Appalachians, from central Pennsylvania south, its thickness is 2,500 feet or more. This, as has been shown by myself[3] and worked out in detail by Berkey,[4] represents a regressional movement of the sea, begun in Lower Beekmantown time and continued throughout; so that the full measure of the depositional series is found only in the non-emerged areas of the Appalachian trough. Northward and westward from this the higher beds fail progressively, the series in central United States being complicated by the desert sands now constituting the St. Peter sandstone. Though it began before the Upper Cambric transgressional movement was fully spent, the greater part of Beekmantown sedimentation was accomplished during a period of emergence of the North American continent.

The Chazy, represented only by its higher beds, the Lowville, in the Mohawk Valley, is nearly 2,500 feet thick in central Pennsylvania, and has a similar thickness in the Appalachians southward. From the region of its greatest thickness, which is also the region of maximum development of the Beekmantown, the Chazy thins northward and westward by failure of its lower members and progressive overlap of its higher. Except in the region of non-emergence, *i. e.*, the Appalachian trough from central Pennsylvania southward, it rests disconformably upon the Beekmantown, the hiatus between the two constantly increasing northward and westward. When present, the St. Peter sandstone marks the plane of this disconformity, though its thickness is no measure of the magnitude of the hiatus. The Chazy thus represents a transgressional series, pronounced in its occurrence over most of North America, but of limited extent in the type region in the St. Lawrence embayment.

[3] SCIENCE, N. S., Vol. XXII., pp. 528–535, October 27, 1905, and *Bull. Geol. Soc. Am.*, Vol. 17, p. 616, 1906.

[4] *Bull. Geol. Soc. Am.*, Vol. 17, pp. 229–250, 1906.

The Black River and Trenton limestones mark the continuance of the transgressive movement. The maximum thickness of the Trenton is less than a thousand feet, and in most places in the east it is partly replaced by the Utica shales. Thus in western New York the limestone referred toTrenton is over 950 feet thick, and the succeeding shales are probably Lorraine with little Utica. Eastward the Utica or black shale phase begins earlier, the higher limestones being replaced by the lower shales. Thus in the type region near Utica the limestone is in the neighborhood of 300 feet thick, and the Utica shale is 700 feet. Still further east, near Amsterdam, the limestone has become reduced to 37 feet, while the shale has increased to over a thousand feet. Northward the limestone increases again to nearly 600 feet in the Montreal region, while the thickness of the shale diminishes. In central Pennsylvania about 700 feet of limestone and 600 feet of shale occur, but in southern Pennsylvania Stose has found that the Trenton is almost entirely replaced by the Utica phase of shale, of which there are almost 1,000 feet of strata. These shales are succeeded by the Eden formation, which in the Cincinnati region rests on Trenton limestone. It thus appears that Trenton limestone and Utica shale represent different lithic and corresponding faunal phases of the same period of sedimentation.

During the succeeding Lower Cincinnati period an extensive retreatal, followed by a readvance movement of the interior North American sea, occurred. As a result, in the marginal portions of this sea, as in the Rocky Mountains, late Richmond rests on early Trenton or earlier beds. In the Appalachian region, extensive continental deposits marked the closing stages of this period, while in the Taconic and Acadian regions, folding was in progress.

As already intimated, three faunas are found in the American Ordovicic: (1) that of the Beekmantown; (2) that of the Chazy; (3) that of the remainder of the series. The Black River fauna is in a measure transi-

tional, and may be classed with either Trenton or Chazy. These faunas and their distinctness in their calcareous as well as graptolitic phases, are well known. The last of these faunas, the Trenton-Cincinnati fauna, is of almost worldwide distribution, characterizing the foreign Upper Ordovicic.

For purposes of intercontinental correlation, the graptolites are most satisfactorily employed. The world over, *Tetragraptus* and *Phyllograptus* characterize the lowest Ordovicic, while *Didymograptus bifidus* further represents the highest part of this lower division. In England, the Arenig rocks include these graptolite zones, and on the continent of Europe and in Australia, etc., this Arenigian division or lower Ordovicic is marked by the same graptolites. In America the shales carrying these graptolites are now regarded as of Beekmantown age, and the correlation of Beekmantown with Arenig is generally accepted. Frech, indeed, draws the line somewhat lower, making the Beekmantown (Calciferous) the equivalent of the Tremadoc and part of the Arenig only. Frech, however, draws the dividing line between the Beekmantown and Chazy below the Fort Cassin beds, so that a part of his Chazy is really Beekmantown in the accepted sense. From this it appears that Lower Ordovicic in America should include the Beekmantown only, applying this term to the formation in its maximum development of 2,500 feet. The term *Beekmantownian* would, therefore, be suitable as an American equivalent of Arenigian or Lower Ordovicic. The Little Falls dolomytes of the Mohawk Valley represent only the lower part of this series, a similar horizon being probably represented by Cushing's "Potsdam" and Theresa formations of northwestern New York. Such a classification would end the Lower Ordovicic with the termination of the great retreatal movement of the sea, which, as shown elsewhere, resulted in the almost complete emergence of the North American continent. The Middle Ordovicic of North America would thus begin with, and be characterized throughout by, an equally great transgressive movement, which, with minor oscillations, again submerged the continent nearly to the extent it had suffered before the emergence.

That the Chazy, with a maximum thickness of 2,500 feet, makes an adequate representation of the Middle Ordovicic can hardly be questioned. Its fauna is distinct, though not without its relationships to both preceding and succeeding faunas. In fact, the Upper Stones River phase of the fauna is so closely related to the Black River fauna that the horizon of the latter is regarded by some as more probably belonging to the Chazy. The Stones River and Lowville faunas seem to be facies faunas of the Chazy, rather than definite indices of the subdivisions of this fauna. Thus while in general the Stones River seems to be a late phase of the Chazy, succeeding the Champlain phase of the Chazy, throughout the interior, the order seems to be reversed in the South Mountain area of Pennsylvania and adjoining districts, where Stose found the Upper Shenandoah to contain a Stones River fauna *followed* by a Chazy-Black River fauna (Chambersburg limestone). Unless there is an error here, the Stones River fauna and typical Chazy fauna (*i. e.*, that of the St. Lawrence embayment) must be considered as contemporaneous. From what has already been said of the relationships of Trenton and Utica deposition, the former must be classed with the Upper Ordovicic. This is further shown by the faunal unity of these formations, many of the most characteristic brachiopods, bryozoa, mollusks and trilobites making their first appearance in the Trenton and continuing through the Cincinnati beds. These types, as already noted, are of wide distribution and are characteristic only of the Upper Ordovicic or Caradocian of Europe and elsewhere, and more especially of the higher zones of this division.

The dividing line between Middle and Upper Ordovicic is drawn in Europe above the zone of *Cœnograptus gracilis*. This graptolite characterizes the Normanskill zone of America, which lies below the Trenton limestone in the Hudson Valley and probably represents Black River horizon if not late Chazy. Ac-

cepting the former equivalency, the dividing line between Middle and Upper Ordovicic should be drawn at the summit of the Black River. This is where Frech draws it, throwing the Trenton limestone into the Upper Ordovicic. In this I believe he is correct, though I am not fully prepared to class the Black River with the lower horizon. Dana's tentative correlation of American and British Ordovicic strata parallels Arenig and Beekmantown, Llandeilo and Chazy, Bala-Caradoc and Trenton, and the lower Llandovery and Utica-Hudson. The lower Llandovery is now referred to the base of the Siluric; the "Hudson" (Lorraine-Richmond) together with the Utica-Trenton thus being referable to the Caradocian.

For the American Middle Ordovicic the term *Chazyan* is here proposed. The old term Canadian would as a result become of no further significance. For the Upper Ordovicic the term *Trentonian* may serve, since Trenton deposition covers at least one half this division. Moreover, the name Trenton Period was used by Dana for Trenton limestone and later divisions. *Nashvillean* would perhaps be a better name, if it is a fact that the Nashville group of Safford covers both Trenton and later Ordovicic formations. *Cincinnatian* is definitely in use for Eden to Richmond inclusive, and though its meaning might be extended to include Trenton limestone, the fact that it is in general use for the higher beds might lead to confusion. The term Mohawkian would, of course, fall into disuse.

In the Appalachian region, extensive fans of continental deposits were formed during late Ordovicic and early Siluric time.[5] In southern Pennsylvania these comprise the basal white beds, generally referred to in the literature as "Oneida," and for which the name *Tyrone* is proposed, from a locality in Pennsylvania where they are typically shown; the middle red beds or Juniata, often called red Medina; and the upper white or Tuscarora, commonly called white Medina. (The Green Pond conglomerates and Longwood shales, and their equivalents in the Delaware and Schuylkill gaps, are not referred to here. They belong in the Salina or Middle Siluric division.) In western New York, the Juniata is represented by the Queenston shales of the present author (red Medina shales of most authors), and the Tuscarora in part by Medina. The Siluro-Ordovicic dividing line falls approximately between these two, *i. e.*, between the Juniata and Tuscarora, or the Bays and Clinch, their southern equivalents. Fossils in the Juniata and Bays (included where the river-laid beds dipped into the sea) indicate their late Ordovicic (Upper Lorraine) age.

The *Siluric* has been discussed in a previous communication (January 6, 1908, SCIENCE, N. S., Vol. XXVII., pp. 622–23, April 17, 1908), and will be more fully treated in the forthcoming article already referred to. The essential points to be noted are: (1) That the Oswegan of Clarke and Schuchert is now known to be in part Ordovicic and in part Salinan. (2) That the Siluric begins with the Medina sandstone (exclusive of Queenston shales) of western New York, which has a thickness of about 100 feet (Upper Medina of authors generally) and contains a fairly abundant fauna of Siluric age, most nearly related to the Clinton. (3) That the Clinton of the type section in eastern New York includes apparently part of the higher Niagaran beds of western New York. (4) That the pre-"Clinton" Siluric beds of the interior (Cape Girardeau beds; Alexandrian beds of T. E. Savage) are to be classed with the Lower Siluric, for which the term *Niagaran,* used by Dana for all these, is to be restored. (5) That the Middle Siluric is represented only in the interior of North America by the non-marine Salina, including the Green Pond-Shawangunk and Longwood beds. (6) That the Monroe formation or *Monroan* of Michigan, Ohio and Canada constitutes the true Upper Siluric, the Cayugan of New York (exclusive of the Salina) representing only the uppermost portion of the Monroe series.

Expressed in tabular form, the classifications here proposed are as follows:

[5] These will be fully discussed in a forthcoming paper by the author.

Siluric or Ontaric.	Upper Siluric or *Monroan* (900–1,000 ft.)	Upper Monroe (including Manlius, Rondout, Cobleskill and Bertie of New York). Middle Monroe (Sylvania sandstone, only known representative). Partly marked by pronounced hiatus. Lower Monroe (including water limes of Ohio, marine "Salina" of Maryland).
	Middle Siluric or *Salinan* (1,000 ft.)	Represented by the non-marine Salina sediments only in North America so far as known (including Green Pond and Shawangunk conglomerates and the red Longwood shales).
	Lower Siluric or *Niagaran* (1,000 ft.)	Guelph. Lockport. Rochester. Clinton. (Limestones and shales of western New York; Medina sandstone, including Oneida conglomerate, Tuscarora sandstone of Pennsylvania and Maryland and Clinch sandstone of Tennessee.) Cape Girardeau or Alexandrian (a possible equivalent of some of the Clinton divisions given above).
Ordovicic or Champlainic.	Upper Ordovicic or *Trentonian* (or Cincinnatian, *sens. lat.*, or Nashvillean) (1,000–1,500 ft.)	Richmond. Lorraine (including non-marine sediments; *i. e.*, Oswego and Queenston sandstones and shales of New York, etc., Tyrone and Juniata conglomerates and sandstones of Pennsylvania; Bays sandstone of Tennessee). Eden formation (probably in part represented by Tyrone conglomerate). Utica—Trenton series.
	Middle Ordovicic or *Chazyan* (2,500 ft.)	Black River (including Normanskill shales). Chazy limestone series of Lake Champlain region, and local facies, such as Lowville, Pamelia, Stones River, Chambersburg beds, etc.
	Lower Ordovicic or *Beekmantownian* (2,500 ft.)	Beekmantown limestones and dolomytes, of Lake Champlain, Deepkill and Levis shales; various local subdivisions, as Little Falls dolomyte and probably the so-called "Potsdam" and Theresa formation of northwest Adirondack region.
Cambric or Taconic.	Upper Cambric or *Bretonian*	Upper part of the St. John group of the Acadian provinces and New Foundland (including Potsdamian and Saratogan as upper members, equivalent approximately to Tremadoc).
	Middle Cambric or *Acadian*	Paradoxides and Protolenus beds of Atlantic province and equivalent beds of Pacific province and Appalachian embayment.
	Lower Cambric or *Etcheminian* ..... or *Georgian*	Etcheminian shales (including Coldbrookian) of Atlantic province (Holmia fauna). Georgia lutytes and arenytes, limestones and dolomytes of Pacific-Appalachian province (Olenellus fauna).

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October, 1908